

REPORT ON GENSTAT AND COREGIONALIZATION

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Abstract

Isatis consists of a large set routines for analysing spatial data by geostatistical methods. The many options are called from menus. It has no facilities for users to do their own programming. Genstat is a general statistical program with its own programming language that enables users to do almost any kind of statistical analysis. In its windows version it provides menus for many options. It includes directives for computing experimental variograms, modelling them, and ordinary kriging, and these are described in detail.

The coregionalization of altitude with climatic variables in the Eastern USA has been computed and modelled. The climatic variables have been kriged, and the kriged estimates have been compared with measured values. In general cokriging was somewhat more precise than autokriging.

Introduction

In this second report of the present contract we summarize the facilities in Genstat (Genstat 5 Committee, 1987) for geostatistical analysis and the results of cokriging using Paul Krause's (TEC) climatic data for the eastern part of the United States of America.

Part I

We were asked to compare the geostatistical package Isatis with Genstat, a much more general statistical written but now containing routines for geostatistics. However, without having Isatis to explore we could not do this adequately or fairly. We treat Isatis very briefly therefore before describing Genstat in more detail.

Isatis is the third of a series of geostatistical programs written by staff of the Centre de Géostatistique of the Paris School of Mines. In these the basic

algorithms have remained much the same, but the interface to the user has been much improved in the light of experience. The program contains a comprehensive set of routines for geostatistical analysis that can be used readily from a menu. This enables the user to progress rapidly in the initial stages of an investigation. It has no programming language, and so if users want facilities that are not in the menu then they must leave the program and resort to other tools. Thus, lack of flexibility might prove a disadvantage, especially when the user has gained expertise in the subject.

Genstat has similarly evolved over time. In its early versions operations were specified by commands. These could be embodied in programs using the Genstat language, and this programming environment is still available. The new version of the program for Windows provides a menu as an alternative, and so users can choose which mode they prefer, and they can switch from to the other. Genstat is very general and powerful. It provides facilities for most of the standard statistical analyses, tabulation and high quality graphics, and the latest release includes advanced techniques based on recent research in statistical computing. It has a large multivariate library. Because it can be programmed it is completely flexible, and there is no need to leave the Genstat environment as demand changes.

Geostatistics in Genstat

Genstat now embodies a suite of techniques for analysing data distributed in a space of one or two dimensions geostatistically. It includes commands for computing experimental variograms and for estimating (predicting) by ordinary kriging, and it has a special procedure for fitting the common non-linear models to experimental variograms.

Starting with a set of data the three operations proceed in sequence, as follows.

- (1) Estimate semivariances at discrete lags to form an ordered set; the sample or experimental variogram.
- (2) Fit plausible models from those allowed to the experimental variogram.
- (3) Krige.

These are called by three directives, which are described below. In many applications the purpose of kriging is to make a map. Values are then kriged at the nodes of a fine grid, through which isarithms, 'contours', can then be threaded. Kriging is implemented in Genstat with this in view.

The FVARIOGRAM directive

The FVARIOGRAM directive forms an experimental variogram from a set of values of a variable, Z , distributed in one or two dimensions using the usual computing formula:

$$\hat{\gamma}(\mathbf{h}) = \frac{1}{2m(\mathbf{h})} \sum_{i=1}^{m(\mathbf{h})} \{z(\mathbf{x}_i) - z(\mathbf{x}_i + \mathbf{h})\}^2, \quad (1)$$

where $z(\mathbf{x}_i)$ and $z(\mathbf{x}_i + \mathbf{h})$ are the values at positions \mathbf{x}_i and $\mathbf{x}_i + \mathbf{h}$, and $m(\mathbf{h})$ is the number of paired comparisons contributing to the estimate. For data on a regular grid or transect \mathbf{h} is an integer multiple of the sampling interval. For irregularly scattered data \mathbf{h} is discretized so that for each nominal lag there is a range of distance equal to the increment (STEP) and an angular range (SEGMENTS) set by the user. The nominal lag is at the centre of both ranges.

Data (DATA) may be on a regular grid and read as a matrix with coordinates implied by columns (X) and rows (Y). Alternatively they may be irregularly scattered, in which case they are read as a variate, and they must have their spatial coordinates provided as X (eastings) and Y (northings), also in variates.

The experimental variogram is controlled by five options. For irregular data the maximum distance to which the variogram is calculated is set by XMAX for all directions. For regular data XMAX defines the maximum lag distance in the X direction, and additionally YMAX must be given to limit the distance in the Y direction. The increment in distance is set by STEP. The variogram may be computed in one or more directions. These are given by DIRECTIONS in degrees counterclockwise from east in the usual mathematical convention. Each direction is at the centre of an angular range, which is defined by SEGMENTS.

A variogram can be computed without regard to direction by setting DIRECTIONS to 0 and SEGMENTS to 180. This is advisable if variation seems to be isotropic, i.e. the same in all directions, or if there are too few data to compute $\hat{\gamma}(\mathbf{h})$ for two or more directions separately. The lag then becomes a scalar $|\mathbf{h}| = h$ in distance only. Experience suggests that some 300 data are needed to distinguish anisotropy.

Statistics are provided by default, and the user can obtain one or more graphs of the variogram by setting GRAPH in the PRINT option.

The final output of FVARIOGRAM is a set of variates as follows.

VARIOGRAMS – the ordered set of semivariances.

DISTANCES – the mean lag distances at which the semivariances have been computed.

DIRECTIONS – the angular separations at which the semivariances have been calculated.

COUNTS – the numbers of paired comparisons from which the semivariances have been computed.

These are tabulated on output in columns in the order DISTANCES, ANGLES, VARIOGRAMS, and COUNTS, from which they can be read for the next stage

of analysis, the fitting of models using MVARIOGRAM.

The MVARIOGRAM procedure

The procedure MVARIOGRAM fits one or more models to the experimental variogram. It uses the Genstat directive FITNONLINEAR. Models must be authorized in the sense that they cannot give rise to negative variances when data are combined. Technically they are conditionally negative semi-definite (CNSD); see Webster & Oliver (1990) or Journel & Huijbregts (1978) for an explanation.

The isotropic models currently available in MVARIOGRAM are:

bounded with finite range – BOUNDEDLINEAR (bounded linear) , CIRCULAR, SPHERICAL, DOUBLESFERICAL (double spherical) and PENTASFERICAL;

bounded asymptotic – EXPONENTIAL, BESSELK1 (Whittle's elementary correlation; Whittle, 1954), and GAUSSIAN.

unbounded – POWERFUNCTION (power function with exponent strictly between 0 and 2), and LINEAR, which is a special case of the power function with exponent 1.

In addition the AFFINEPOWER function may be fitted to an experimental variogram that appears unbounded and geometrically anisotropic, i.e. one that might be made isotropic by a simple linear transformation of the spatial coordinates.

The procedure takes a table of DISTANCES, ANGLES, VARIOGRAMS, and COUNTS, as produced by FVARIOGRAM, and it attempts to fit in turn the models specified by the user by estimating their parameters. It weights the entries in the experimental variogram, either by the COUNTS, or by a combination of COUNTS and VARIOGRAM using the setting CBYVAR, or equally using the setting EQUAL. The model may be fitted with an intercept (a constant, the 'nugget'

variance, see below) by setting ESTIMATE, or through the origin with the setting OMIT.

Output from the procedure includes convergence monitoring, an analysis of variance, and the estimated values of the parameters, distinguishing the non-linear from the linear.

The procedure contains or calculates from the variogram rough starting values for the parameters. These are then refined by FITNONLINEAR to convergence. If the solution does not converge there are two likely reasons.

1. The model is unsuited for the particular experimental variogram. For example, a bounded model is specified when the variogram is clearly unbounded, or *vice versa*. The user should choose only variograms that have approximately the right shape.
2. The starting values are too far from a sensible solution. Here the user should estimate starting values by inspection and insert them into MVARIOGRAM.

The KRIGE directive

The KRIGE directive computes the ordinary kriging estimates of a variable at positions on a grid from data and a model variogram by solving the kriging system.

The DATA must be in one of the two forms as for FVARIOGRAM, i.e. as a matrix on a rectangular grid with spatial coordinates implied, or as a variate with the coordinates in X (eastings) and Y (northings) supplied as additional variates. By default all data are considered when forming the kriging system. However, a subset of the data may be selected by limiting the area to a rectangle defined by XOUTER, the left (western) and right (eastern) limits, and YOUTER, the bottom (southern) and top (northern) limits.

The positions at which Z is estimated (predicted) are contained in a rectangle defined by XINNER and YINNER and INTERVAL. XINNER and YINNER are specified in the same way as XOUTER and YOUTER, and their limits should lie within those of XOUTER and YOUTER. The option INTERVAL is the distance between successive positions in the rows and columns of the grid at which kriging is to be done. INTERVAL is specified in the same units as the data. However, if the aim is to make a map then INTERVAL should be chosen so that it is no more than 2 mm on the final document. By doing this the optimality of kriging will not be noticeably degraded by the subsequent contouring.

Kriging may be either punctual, i.e. at 'points' which have the same size and shape as the sample support, or on bigger rectangular blocks. The size of the blocks is specified by BLOCK, the lengths of the block in the x direction (eastings) and y direction (northings). Punctual kriging is the default. Alternatively it can be specified by giving both values as 0. The average semivariances between point and block, $\bar{\gamma}(\mathbf{h})$ and $\bar{\gamma}(B, B)$ in the kriging system, are computed by integrating the variogram numerically over the block. The number of steps in each direction is given by NSTEP. The default is 8, and is recommended. The kriging may be accelerated by reducing NSTEP at the expense of accuracy, and accuracy gained by increasing it but by taking more time. The minimum is 4 and the maximum 10.

The minimum and maximum number of points for the kriging system, n in kriging equations, are set by MINPTS and MAXPTS. Their limits are a minimum of 3 for MINPTS and a maximum of 40 for MAXPTS, and MINPTS must be less than or equal to MAXPTS. The defaults are 7 and 20 respectively. Data points may be selected around the point or block to be kriged by setting a RADIUS within which they must lie. If the variogram is anisotropic then the SEARCH

may also be ANISOTROPIC. The default is ISOTROPIC.

Further options are available for gridded data. Universal kriging may be invoked by setting the DRIFT to LINEAR or to QUADRATIC, i.e. of order 1 or 2 respectively. The default is CONSTANT for ordinary kriging. If the grid is not square then the ratio of the spacing in the y direction to that in the x direction is given by YXRATIO. The default is 1.0 for square. Missing data on the grid may be interpolated by punctual kriging as a preliminary by setting INTERPOLATE to YES. The default is NO.

The variogram is specified by its type and parameters, as follows. The MODEL may be of any of POWER, BOUNDEDLINEAR (one dimension only), CIRCULAR, SPHERICAL, PENTASPHERICAL, DOUBLESPPHERICAL, EXPONENTIAL, GAUSSIAN, and BESSELK1 (Whittle's function). All models may have a NUGGET, which is the constant from MVARIOGRAM. The POWER function (the only unbounded model) has a GRADIENT and EXPONENT. The simple bounded models, i.e. all others except DOUBLESPPHERICAL, have SILLVARIANCES (the sill of the correlated variance) and RANGES. The latter is strictly the correlation range of the BOUNDEDLINEAR, CIRCULAR, SPHERICAL AND PENTASPHERICAL models, and for the asymptotic ones it is the distance parameter of the model. The DOUBLESPPHERICAL model has two SILLVARIANCES and two RANGES corresponding to the two components of the model.

The ISOTROPY may be ISOTROPIC or anisotropic. In the latter case it may be either BURGESS anisotropy (Burgess & Webster, 1980) or GEOMETRIC anisotropy (Journel & Huijbregts, 1978; Webster & Oliver, 1990), and the anisotropy must be specified by three parameters, namely PHI, the angle in radians of the direction of maximum variation, RMAX, the maximum gradient of the model, and RMIN, the minimum gradient. In the present release only the

POWER function may be anisotropic.

The output consists of two matrices, one of estimates (predictions) in ESTIMATES, and the other of the estimation (prediction or kriging) variances in VARIANCES. The matrices are arranged with the first row of each matrix at the bottom following geographic rather than mathematical convention, ready for mapping.

Intermediate results may be printed optionally by settings of PRINT. SEARCH will list the results of the search for data around each position to be kriged. WEIGHTS will list the kriging weights at each position. MONITOR will monitor the formation and inversion of the kriging matrices for each position. These options enable the user to check that the kriging is working reasonably. They can produce a great deal of output, and they should not be requested when kriging large matrices, such as might be wanted for mapping. The option DATA will print the data.

Part II

Paul Krause (TEC) provided us with data from 177 weather recording stations in the eastern USA for geostatistical analysis. The full set of data was divided into two subsets; one consisting of 121 sites, the other of 56 sites that constituted a validation set at which estimates from the first could be compared with recorded values. The variables in the data were height, potential evaporation, continentality, mrange and temperature. We computed auto and cross variograms for these properties. The auto variograms were then modelled using Ross's MLP (Maximum Likelihood Program) (Ross, 1987). This was while Margaret Oliver was at

TEC in February 1996. Using these variograms and both the full and test sets of data the values of each property at more than 5000 locations were estimated by ordinary autokriling. Both sets of estimates for temperature were then used for mapping. The autokrined estimates for the test data matched those of the full set well.

Table 1 summarizes the data. Among other things it shows that height was strongly skewed, and that taking square roots of height made the distribution more nearly symmetric and would thereby stabilize variances in later analysis. The correlations between the variables (Table 2) were weak to moderate. Of particular interest were the correlations between height and the climatic variables (column 2, Table 2). That for height and mrange was the strongest, while that between height and temperature was the weakest.

The coregionalization of height and each of the other variables separately was computed and modelled. All the models were power functions, but with different exponents. Table 3 lists the parameters of the models.

The four variables potential evaporation, continentality, mrange and temperature were then estimated at the 56 validation sites by ordinary kriging in three ways. These were:

- 1) autokriling from the 121 sites of the first set of data;
- 2) cokriging from the 121 sites; and
- 3) cokriging from the test variable and height at the 121 sites plus height at the 56 validation sites.
- 4) In addition, because we knew the height at all the sites of the validation set, we could use simple regression to predict the target variables, and this we did.

For each method and for each point we computed the error as the difference be-

tween the estimate and the recorded value, the squared error and the kriging variance. We then computed their averages and the ratio of the mean squared error to the kriging variance.

Results

The individual estimates at the 56 validation sites and their variances are given in Tables 5 to 8 as an appendix together with the measured values there. The summaries are tabulated in Table 4.

Table 4 shows that the bias, as represented by the mean error, is negligible. The kriging variance diminishes consistently as more information is included, as it should. Autokriging incurs the largest kriging variances, cokriging with height known at the validation points incurs the least. The mean squared errors, however, are least for the autokriging. This suggests that the linear model of coregionalization does not describe the data well. The Table also shows that simple regression is a relatively poor predictor. This is partly because the correlations are weak and partly because it takes no account of the spatial dependence in the data. Simple regression is not a satisfactory means of prediction in these circumstances.

References

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Table 1. Summary statistics.

| | Height | Square root height | Potential evapo- transpiration | Contin- entality | Mrange | Temp- erature |
|---------------|---------|--------------------------|--------------------------------------|---------------------|--------|------------------|
| Minimum | 3 | 1.7 | 19.2 | 9.3 | 42 | 23.0 |
| Maximum | 3945 | 62.8 | 197.3 | 59.3 | 106 | 76.7 |
| Mean | 676 | 22.0 | 82.9 | 40.1 | 84.7 | 48.9 |
| Median | 500 | 22.3 | 83.8 | 41.1 | 86 | 46.2 |
| St. deviation | 767 | 13.9 | 31.2 | 9.19 | 11.0 | 13.3 |
| Variance | 588 450 | 194.4 | 973.5 | 84.34 | 120.5 | 178.5 |
| Skew | 2.0 | 0.57 | 0.84 | -0.70 | -0.91 | 0.28 |

Table 2. Correlation matrix in lower triangle

| | | | | | | |
|------------------------------|--------|--------|--------|--------|---|--|
| Square root height | 1 | | | | | |
| Potential evapotranspiration | -0.354 | 1 | | | | |
| Continentalty | 0.607 | -0.158 | 1 | | | |
| Mrange | 0.703 | -0.248 | 0.770 | 1 | | |
| Temperature | -0.440 | -0.272 | -0.776 | -0.495 | 1 | |

Table 3. Coregionalization models, parameters in lower triangle with the target variable first.

| | | | | |
|------------------------------------|-------------------------|-------|-------|--|
| PE \times height | exponent | 1.2 | | |
| | Nugget variance | | | |
| | Potential transpiration | 10.85 | | |
| | Square root height | 25.52 | 60.03 | |
| | Gradient | | | |
| | Potential transpiration | 31.14 | | |
| Continental ity \times height | exponent | 1.4 | | |
| | Nugget variance | | | |
| | Continental ity | 5.86 | | |
| | Square root height | -6.96 | 51.00 | |
| | Gradient | | | |
| | Potential transpiration | 2.38 | | |
| Mrange \times height | exponent | 1.0 | | |
| | Nugget variance | | | |
| | Mrange | 12.58 | | |
| | Square root height | 2.82 | 39.36 | |
| | Gradient | | | |
| | Potential transpiration | 8.26 | | |
| Temperature \times height | exponent | 1.2 | | |
| | Nugget variance | | | |
| | Temperature | 0.60 | | |
| | Square root height | 5.30 | 46.85 | |
| | Gradient | | | |
| | Temperature | 9.40 | | |
| | Square root height | -5.25 | 5.80 | |

Table 4. Summaries of kriging errors. Cokriging (121) means cokriging the target variable with data from only the 121 test sites; cokriging (121+56) means cokriging it with data from the 121 test sites plus height at the target points.

| | Mean error | Mean squared error | kriging variance | Variance ratio |
|--------------------------------|---------------|-----------------------|---------------------|-------------------|
| Height \times PE | | | | |
| Autokriging | -0.03 | 45.0 | 54.2 | 0.83 |
| Cokriging (121) | -0.32 | 52.4 | 50.7 | 1.03 |
| Cokriging (121+56) | -0.27 | 46.3 | 44.7 | 1.04 |
| Regression | -1.92 | 804.0 | 887.3 | 0.91 |
| Height \times Continentality | | | | |
| Autokriging | 0.08 | 2.35 | 10.4 | 0.23 |
| Cokriging (121) | 0.21 | 2.96 | 9.97 | 0.30 |
| Cokriging (121+56) | 0.19 | 2.53 | 9.65 | 0.26 |
| Regression | 1.24 | 51.55 | 55.07 | 0.94 |
| Height \times Mrange | | | | |
| Autokriging | 0.18 | 25.31 | 27.13 | 0.93 |
| Cokriging (121) | 0.25 | 25.15 | 26.88 | 0.94 |
| Cokriging (121+56) | 0.24 | 26.21 | 22.57 | 1.16 |
| Regression | 0.91 | 69.35 | 58.09 | 1.19 |
| Height \times Temperature | | | | |
| Autokriging | -0.16 | 2.35 | 12.50 | 0.19 |
| Cokriging (121) | -0.25 | 2.55 | 12.27 | 0.21 |
| Cokriging (121+56) | -0.25 | 2.75 | 11.94 | 0.23 |
| Regression | -0.72 | 145.7 | 299.4 | 0.49 |

APPENDIX

Tables of measured and estimated values

Potential Evapotranspiration

| X | Y | ESTIMATE | VARIANCE | ESTIMATE | VARIANCE | ESTIMATE | VARIANCE | PE |
|-------|--------|-------------|------------|-----------|------------|-----------|---------------|----------|
| | | Autokriging | 121 points | Cokriging | 121 points | Cokriging | 121+56 points | Original |
| 35.33 | 94.37 | 6.94E+01 | 8.04E+01 | 7.53E+01 | 6.78E+01 | 7.50E+01 | 6.44E+01 | 7.47E+01 |
| 34.73 | 92.23 | 4.97E+01 | 8.19E+01 | 8.60E+01 | 7.83E+01 | 8.50E+01 | 7.62E+01 | 9.58E+01 |
| 41.93 | 72.68 | 2.03E+01 | 7.42E+01 | 1.05E+02 | 4.43E+01 | 1.05E+02 | 3.84E+01 | 1.21E+02 |
| 38.85 | 77.03 | 2.97E+01 | 7.10E+01 | 8.59E+01 | 2.28E+01 | 8.13E+01 | 1.30E+01 | 7.74E+01 |
| 39.67 | 75.6 | 2.38E+01 | 7.01E+01 | 9.46E+01 | 2.65E+01 | 9.26E+01 | 1.77E+01 | 9.32E+01 |
| 30.22 | 81.88 | 9.20E+00 | 7.14E+01 | 6.95E+01 | 2.01E+01 | 6.90E+01 | 9.61E+00 | 7.31E+01 |
| 24.58 | 81.68 | 9.80E-01 | 8.27E+01 | 5.05E+01 | 1.67E+01 | 4.83E+01 | 3.29E+00 | 4.75E+01 |
| 32.52 | 84.95 | 4.54E+01 | 7.37E+01 | 8.90E+01 | 4.40E+01 | 8.94E+01 | 3.81E+01 | 8.53E+01 |
| 32.13 | 81.2 | 1.97E+01 | 7.27E+01 | 7.73E+01 | 3.34E+01 | 7.54E+01 | 2.56E+01 | 7.40E+01 |
| 41.98 | 87.9 | 7.26E+01 | 7.49E+01 | 8.91E+01 | 4.85E+01 | 8.91E+01 | 4.20E+01 | 8.29E+01 |
| 41.53 | 93.65 | 9.98E+01 | 7.81E+01 | 7.06E+01 | 6.29E+01 | 7.07E+01 | 5.94E+01 | 6.60E+01 |
| 42.08 | 87.83 | 7.28E+01 | 7.49E+01 | 8.89E+01 | 4.86E+01 | 8.87E+01 | 4.21E+01 | 8.33E+01 |
| 41.45 | 90.5 | 8.01E+01 | 7.72E+01 | 7.87E+01 | 5.75E+01 | 7.77E+01 | 5.31E+01 | 8.28E+01 |
| 40.67 | 89.68 | 7.21E+01 | 7.59E+01 | 8.08E+01 | 4.14E+01 | 8.05E+01 | 3.46E+01 | 8.01E+01 |
| 41 | 85.2 | 7.48E+01 | 7.30E+01 | 9.12E+01 | 4.36E+01 | 9.16E+01 | 3.77E+01 | 9.01E+01 |
| 38.03 | 84.6 | 8.63E+01 | 7.42E+01 | 9.43E+01 | 4.40E+01 | 9.52E+01 | 3.80E+01 | 1.01E+02 |
| 29.98 | 90.25 | 7.42E+00 | 7.45E+01 | 9.54E+01 | 2.24E+01 | 9.35E+01 | 1.19E+01 | 9.34E+01 |
| 38.28 | 76.42 | 1.93E+01 | 7.18E+01 | 8.59E+01 | 3.68E+01 | 8.33E+01 | 2.98E+01 | 8.35E+01 |
| 45.07 | 83.57 | 6.84E+01 | 8.43E+01 | 9.29E+01 | 7.16E+01 | 9.34E+01 | 6.84E+01 | 7.83E+01 |
| 42.97 | 83.75 | 7.23E+01 | 7.57E+01 | 8.54E+01 | 4.48E+01 | 8.52E+01 | 3.86E+01 | 7.58E+01 |
| 42.77 | 84.6 | 7.24E+01 | 7.44E+01 | 8.67E+01 | 4.10E+01 | 8.73E+01 | 3.42E+01 | 7.82E+01 |
| 46.83 | 92.18 | 1.10E+02 | 8.99E+01 | 6.11E+01 | 8.93E+01 | 6.15E+01 | 8.72E+01 | 7.80E+01 |
| 44.88 | 93.22 | 1.12E+02 | 8.28E+01 | 6.00E+01 | 6.42E+01 | 5.85E+01 | 6.00E+01 | 5.93E+01 |
| 38.82 | 92.22 | 8.08E+01 | 7.92E+01 | 7.84E+01 | 6.49E+01 | 7.86E+01 | 6.14E+01 | 8.54E+01 |
| 32.32 | 90.08 | 2.50E+01 | 7.72E+01 | 9.59E+01 | 6.04E+01 | 9.69E+01 | 5.66E+01 | 9.88E+01 |
| 32.33 | 88.75 | 2.58E+01 | 7.37E+01 | 9.96E+01 | 2.38E+01 | 1.01E+02 | 1.38E+01 | 9.70E+01 |
| 35.27 | 75.55 | 2.62E+00 | 8.53E+01 | 8.83E+01 | 8.08E+01 | 8.71E+01 | 7.84E+01 | 1.00E+02 |
| 35.22 | 80.93 | 7.40E+01 | 7.24E+01 | 8.47E+01 | 4.22E+01 | 8.59E+01 | 3.62E+01 | 8.01E+01 |
| 34.9 | 76.88 | 7.29E+00 | 7.74E+01 | 8.88E+01 | 3.77E+01 | 8.79E+01 | 2.98E+01 | 8.96E+01 |
| 46.9 | 96.8 | 1.44E+02 | 9.34E+01 | 4.81E+01 | 1.19E+02 | 4.79E+01 | 1.19E+02 | 4.10E+01 |
| 42.87 | 100.55 | 2.43E+02 | 8.11E+01 | 3.63E+01 | 7.40E+01 | 3.67E+01 | 7.14E+01 | 3.38E+01 |
| 39.45 | 74.57 | 1.64E+01 | 7.29E+01 | 9.81E+01 | 3.40E+01 | 9.80E+01 | 2.63E+01 | 9.56E+01 |
| 42.22 | 75.98 | 4.37E+01 | 7.19E+01 | 9.51E+01 | 3.44E+01 | 1.02E+02 | 2.70E+01 | 1.02E+02 |
| 40.65 | 73.78 | 1.90E+01 | 7.22E+01 | 1.02E+02 | 1.88E+01 | 9.84E+01 | 7.95E+00 | 9.49E+01 |
| 40.92 | 81.43 | 8.21E+01 | 7.33E+01 | 9.36E+01 | 3.19E+01 | 9.63E+01 | 2.38E+01 | 9.31E+01 |
| 35.4 | 97.6 | 1.36E+02 | 8.06E+01 | 5.08E+01 | 7.25E+01 | 5.14E+01 | 6.94E+01 | 5.41E+01 |
| 42.83 | 80.18 | 6.96E+01 | 7.63E+01 | 9.54E+01 | 4.49E+01 | 9.64E+01 | 3.88E+01 | 1.06E+02 |
| 40.5 | 80.22 | 7.74E+01 | 7.54E+01 | 9.49E+01 | 4.70E+01 | 9.70E+01 | 4.16E+01 | 9.22E+01 |
| 35.03 | 85.2 | 7.56E+01 | 7.57E+01 | 9.91E+01 | 5.68E+01 | 9.96E+01 | 5.25E+01 | 1.09E+02 |
| 35.8 | 84 | 9.41E+01 | 7.52E+01 | 9.25E+01 | 5.84E+01 | 9.32E+01 | 5.45E+01 | 9.60E+01 |
| 36.12 | 86.68 | 6.35E+01 | 7.74E+01 | 1.05E+02 | 5.85E+01 | 1.06E+02 | 5.44E+01 | 9.69E+01 |
| 32.42 | 99.68 | 1.67E+02 | 7.95E+01 | 3.06E+01 | 6.15E+01 | 3.18E+01 | 5.73E+01 | 3.33E+01 |
| 35.23 | 101.7 | 2.72E+02 | 8.55E+01 | 2.46E+01 | 7.64E+01 | 2.64E+01 | 7.36E+01 | 2.94E+01 |
| 25.9 | 97.43 | 2.65E+01 | 9.66E+01 | 4.01E+01 | 1.16E+02 | 3.89E+01 | 1.15E+02 | 3.14E+01 |
| 27.7 | 97.28 | 2.36E+01 | 7.53E+01 | 4.25E+01 | 2.25E+01 | 3.92E+01 | 1.17E+01 | 3.64E+01 |
| 32.9 | 97.03 | 8.45E+01 | 7.62E+01 | 5.14E+01 | 2.02E+01 | 5.03E+01 | 8.99E+00 | 4.92E+01 |
| 29.97 | 95.35 | 2.06E+01 | 7.71E+01 | 6.89E+01 | 5.43E+01 | 6.84E+01 | 4.96E+01 | 6.95E+01 |
| 29.53 | 98.47 | 7.49E+01 | 7.81E+01 | 3.47E+01 | 6.12E+01 | 3.54E+01 | 5.72E+01 | 4.00E+01 |
| 33.97 | 98.48 | 1.47E+02 | 8.14E+01 | 4.17E+01 | 7.95E+01 | 4.05E+01 | 7.69E+01 | 4.21E+01 |
| 36.93 | 76.28 | 1.14E+01 | 7.20E+01 | 8.53E+01 | 1.54E+01 | 8.26E+01 | 3.59E+00 | 7.10E+01 |
| 38.95 | 77.45 | 3.69E+01 | 7.18E+01 | 8.60E+01 | 2.85E+01 | 8.15E+01 | 1.99E+01 | 8.90E+01 |
| 42.95 | 87.9 | 7.47E+01 | 7.50E+01 | 8.28E+01 | 4.69E+01 | 8.24E+01 | 4.08E+01 | 8.04E+01 |
| 37.78 | 81.12 | 9.39E+01 | 7.32E+01 | 8.59E+01 | 3.58E+01 | 9.30E+01 | 2.84E+01 | 9.64E+01 |
| 44.88 | 63.52 | 1.82E+01 | 8.05E+01 | 1.79E+02 | 2.43E+01 | 1.84E+02 | 1.32E+01 | 1.88E+02 |
| 46.8 | 71.38 | 2.54E+01 | 9.60E+01 | 1.44E+02 | 1.34E+02 | 1.44E+02 | 1.34E+02 | 1.25E+02 |
| 43.9 | 69.93 | 1.78E+01 | 7.82E+01 | 1.44E+02 | 3.39E+01 | 1.43E+02 | 2.54E+01 | 1.42E+02 |

Continentality

| X | Y | ESTIMATE | VARIANCE | ESTIMATE | VARIANCE | ESTIMATE | VARIANCE | Continentality |
|-------|--------|-------------|------------|-----------|------------|-----------|---------------|----------------|
| | | Autokriging | 121 points | Cokriging | 121 points | Cokriging | 121+56 points | Original |
| 35.33 | 94.37 | 4.33E+01 | 1.16E+01 | 4.35E+01 | 1.12E+01 | 4.37E+01 | 1.10E+01 | 4.44E+01 |
| 34.73 | 92.23 | 3.85E+01 | 1.25E+01 | 3.89E+01 | 1.20E+01 | 3.90E+01 | 1.20E+01 | 4.24E+01 |
| 41.93 | 72.68 | 4.21E+01 | 9.33E+00 | 4.18E+01 | 9.07E+00 | 4.17E+01 | 8.71E+00 | 4.36E+01 |
| 38.85 | 77.03 | 3.97E+01 | 8.06E+00 | 3.89E+01 | 7.73E+00 | 3.99E+01 | 7.10E+00 | 3.99E+01 |
| 39.67 | 75.6 | 4.07E+01 | 7.98E+00 | 4.00E+01 | 7.77E+00 | 4.08E+01 | 7.18E+00 | 4.05E+01 |
| 30.22 | 81.88 | 2.64E+01 | 7.97E+00 | 2.55E+01 | 7.61E+00 | 2.56E+01 | 6.96E+00 | 2.70E+01 |
| 24.58 | 81.68 | 1.11E+01 | 9.69E+00 | 1.20E+01 | 8.83E+00 | 1.15E+01 | 8.26E+00 | 9.30E+00 |
| 32.52 | 84.95 | 3.57E+01 | 9.29E+00 | 3.59E+01 | 9.00E+00 | 3.57E+01 | 8.66E+00 | 3.49E+01 |
| 32.13 | 81.2 | 3.16E+01 | 8.76E+00 | 3.04E+01 | 8.45E+00 | 3.09E+01 | 8.00E+00 | 3.25E+01 |
| 41.98 | 87.9 | 4.77E+01 | 9.67E+00 | 4.75E+01 | 9.39E+00 | 4.76E+01 | 8.93E+00 | 4.83E+01 |
| 41.53 | 93.65 | 5.38E+01 | 1.10E+01 | 5.33E+01 | 1.06E+01 | 5.36E+01 | 1.05E+01 | 5.35E+01 |
| 42.08 | 87.83 | 4.75E+01 | 9.64E+00 | 4.74E+01 | 9.36E+00 | 4.75E+01 | 8.90E+00 | 4.71E+01 |
| 41.45 | 90.5 | 5.12E+01 | 1.04E+01 | 5.08E+01 | 1.01E+01 | 5.13E+01 | 9.88E+00 | 5.12E+01 |
| 40.67 | 89.68 | 4.98E+01 | 9.66E+00 | 4.93E+01 | 9.23E+00 | 4.95E+01 | 8.88E+00 | 4.95E+01 |
| 41 | 85.2 | 4.49E+01 | 9.13E+00 | 4.50E+01 | 8.89E+00 | 4.51E+01 | 8.54E+00 | 4.68E+01 |
| 38.03 | 84.6 | 4.23E+01 | 9.46E+00 | 4.20E+01 | 9.15E+00 | 4.17E+01 | 8.83E+00 | 4.19E+01 |
| 29.98 | 90.25 | 3.02E+01 | 8.57E+00 | 2.95E+01 | 8.09E+00 | 3.00E+01 | 7.52E+00 | 2.86E+01 |
| 38.28 | 76.42 | 3.87E+01 | 8.55E+00 | 3.76E+01 | 8.32E+00 | 3.83E+01 | 7.87E+00 | 3.91E+01 |
| 45.07 | 83.57 | 4.33E+01 | 1.22E+01 | 4.31E+01 | 1.16E+01 | 4.31E+01 | 1.16E+01 | 4.24E+01 |
| 42.97 | 83.75 | 4.39E+01 | 9.74E+00 | 4.36E+01 | 9.38E+00 | 4.36E+01 | 9.02E+00 | 4.40E+01 |
| 42.77 | 84.6 | 4.40E+01 | 9.24E+00 | 4.39E+01 | 8.93E+00 | 4.36E+01 | 8.51E+00 | 4.41E+01 |
| 46.83 | 92.18 | 5.52E+01 | 1.38E+01 | 5.50E+01 | 1.33E+01 | 5.52E+01 | 1.32E+01 | 5.14E+01 |
| 44.88 | 93.22 | 5.58E+01 | 1.18E+01 | 5.57E+01 | 1.13E+01 | 5.63E+01 | 1.11E+01 | 5.76E+01 |
| 38.82 | 92.22 | 4.82E+01 | 1.12E+01 | 4.83E+01 | 1.08E+01 | 4.85E+01 | 1.07E+01 | 4.87E+01 |
| 32.32 | 90.08 | 3.43E+01 | 1.07E+01 | 3.43E+01 | 1.04E+01 | 3.41E+01 | 1.02E+01 | 3.79E+01 |
| 32.33 | 88.75 | 3.55E+01 | 8.86E+00 | 3.59E+01 | 8.37E+00 | 3.57E+01 | 7.87E+00 | 3.51E+01 |
| 35.27 | 75.55 | 3.44E+01 | 1.32E+01 | 3.27E+01 | 1.26E+01 | 3.33E+01 | 1.26E+01 | 3.12E+01 |
| 35.22 | 80.93 | 3.66E+01 | 9.02E+00 | 3.76E+01 | 8.79E+00 | 3.71E+01 | 8.42E+00 | 3.66E+01 |
| 34.9 | 76.88 | 3.42E+01 | 9.67E+00 | 3.31E+01 | 9.19E+00 | 3.36E+01 | 8.75E+00 | 3.28E+01 |
| 46.9 | 96.8 | 5.71E+01 | 1.63E+01 | 5.63E+01 | 1.58E+01 | 5.62E+01 | 1.58E+01 | 5.93E+01 |
| 42.87 | 100.55 | 5.05E+01 | 1.20E+01 | 5.14E+01 | 1.16E+01 | 5.13E+01 | 1.16E+01 | 5.12E+01 |
| 39.45 | 74.57 | 3.98E+01 | 8.84E+00 | 3.89E+01 | 8.53E+00 | 3.88E+01 | 8.10E+00 | 4.07E+01 |
| 42.22 | 75.98 | 4.28E+01 | 8.66E+00 | 4.38E+01 | 8.37E+00 | 4.18E+01 | 7.91E+00 | 4.22E+01 |
| 40.65 | 73.78 | 4.09E+01 | 8.33E+00 | 3.99E+01 | 7.91E+00 | 4.05E+01 | 7.34E+00 | 3.97E+01 |
| 40.92 | 81.43 | 4.20E+01 | 8.76E+00 | 4.25E+01 | 8.37E+00 | 4.17E+01 | 7.89E+00 | 4.20E+01 |
| 35.4 | 97.6 | 4.70E+01 | 1.18E+01 | 4.67E+01 | 1.14E+01 | 4.66E+01 | 1.13E+01 | 4.70E+01 |
| 42.83 | 80.18 | 4.26E+01 | 9.67E+00 | 4.30E+01 | 9.28E+00 | 4.25E+01 | 8.96E+00 | 3.99E+01 |
| 40.5 | 80.22 | 4.08E+01 | 1.00E+01 | 4.14E+01 | 9.63E+00 | 4.13E+01 | 9.41E+00 | 4.11E+01 |
| 35.03 | 85.2 | 3.93E+01 | 1.03E+01 | 4.03E+01 | 1.00E+01 | 4.01E+01 | 9.79E+00 | 3.94E+01 |
| 35.8 | 84 | 3.83E+01 | 1.03E+01 | 3.98E+01 | 1.00E+01 | 3.92E+01 | 9.82E+00 | 3.87E+01 |
| 36.12 | 86.68 | 4.17E+01 | 1.07E+01 | 4.14E+01 | 1.04E+01 | 4.13E+01 | 1.02E+01 | 4.10E+01 |
| 32.42 | 99.68 | 4.23E+01 | 1.10E+01 | 4.36E+01 | 1.06E+01 | 4.31E+01 | 1.04E+01 | 4.20E+01 |
| 35.23 | 101.7 | 4.44E+01 | 1.28E+01 | 4.68E+01 | 1.23E+01 | 4.60E+01 | 1.23E+01 | 4.32E+01 |
| 25.9 | 97.43 | 2.78E+01 | 1.74E+01 | 2.66E+01 | 1.66E+01 | 2.66E+01 | 1.65E+01 | 2.63E+01 |
| 27.7 | 97.28 | 3.06E+01 | 8.34E+00 | 2.95E+01 | 8.00E+00 | 3.02E+01 | 7.29E+00 | 2.92E+01 |
| 32.9 | 97.03 | 4.31E+01 | 9.10E+00 | 4.26E+01 | 8.45E+00 | 4.31E+01 | 7.96E+00 | 4.29E+01 |
| 29.97 | 95.35 | 3.42E+01 | 1.03E+01 | 3.30E+01 | 1.00E+01 | 3.36E+01 | 9.80E+00 | 3.31E+01 |
| 29.53 | 98.47 | 3.60E+01 | 1.07E+01 | 3.61E+01 | 1.05E+01 | 3.59E+01 | 1.03E+01 | 3.64E+01 |
| 33.97 | 98.48 | 4.51E+01 | 1.23E+01 | 4.54E+01 | 1.20E+01 | 4.55E+01 | 1.18E+01 | 4.59E+01 |
| 36.93 | 76.28 | 3.64E+01 | 7.88E+00 | 3.52E+01 | 7.47E+00 | 3.64E+01 | 6.77E+00 | 3.64E+01 |
| 38.95 | 77.45 | 3.98E+01 | 8.48E+00 | 3.89E+01 | 8.14E+00 | 4.00E+01 | 7.61E+00 | 4.24E+01 |
| 42.95 | 87.9 | 4.78E+01 | 9.42E+00 | 4.76E+01 | 9.15E+00 | 4.76E+01 | 8.72E+00 | 4.64E+01 |
| 37.78 | 81.12 | 3.83E+01 | 8.93E+00 | 3.95E+01 | 8.59E+00 | 3.71E+01 | 8.17E+00 | 3.70E+01 |
| 44.88 | 63.52 | 3.26E+01 | 9.66E+00 | 3.31E+01 | 8.99E+00 | 3.22E+01 | 8.49E+00 | 3.56E+01 |
| 46.8 | 71.38 | 4.69E+01 | 1.82E+01 | 4.63E+01 | 1.76E+01 | 4.59E+01 | 1.74E+01 | 5.03E+01 |
| 43.9 | 69.93 | 4.07E+01 | 9.95E+00 | 4.01E+01 | 9.38E+00 | 4.04E+01 | 9.02E+00 | 4.21E+01 |

| X | Y | ESTIMATE | VARIANCE | ESTIMATE | VARIANCE | ESTIMATE | VARIANCE | Mrange |
|-------|--------|-------------|------------|-----------|------------|-----------|---------------|----------|
| | | Autokriging | 121 points | Cokriging | 121 points | Cokriging | 121+56 points | Original |
| 35.33 | 94.37 | 8.53E+01 | 3.12E+01 | 8.56E+01 | 3.09E+01 | 8.45E+01 | 2.50E+01 | 9.10E+01 |
| 34.73 | 92.23 | 8.37E+01 | 3.34E+01 | 8.39E+01 | 3.32E+01 | 8.25E+01 | 2.61E+01 | 8.70E+01 |
| 41.93 | 72.68 | 8.55E+01 | 2.51E+01 | 8.52E+01 | 2.49E+01 | 8.52E+01 | 2.15E+01 | 9.20E+01 |
| 38.85 | 77.03 | 8.38E+01 | 2.02E+01 | 8.31E+01 | 2.00E+01 | 8.09E+01 | 1.83E+01 | 8.40E+01 |
| 39.67 | 75.6 | 8.25E+01 | 2.05E+01 | 8.21E+01 | 2.04E+01 | 8.15E+01 | 1.86E+01 | 8.90E+01 |
| 30.22 | 81.88 | 7.61E+01 | 1.94E+01 | 7.51E+01 | 1.91E+01 | 7.51E+01 | 1.78E+01 | 7.90E+01 |
| 24.58 | 81.68 | 4.88E+01 | 2.21E+01 | 5.04E+01 | 2.15E+01 | 5.16E+01 | 1.99E+01 | 4.20E+01 |
| 32.52 | 84.95 | 8.45E+01 | 2.49E+01 | 8.46E+01 | 2.47E+01 | 8.46E+01 | 2.14E+01 | 8.50E+01 |
| 32.13 | 81.2 | 7.88E+01 | 2.30E+01 | 7.78E+01 | 2.27E+01 | 7.68E+01 | 2.02E+01 | 8.10E+01 |
| 41.98 | 87.9 | 8.83E+01 | 2.60E+01 | 8.84E+01 | 2.59E+01 | 8.83E+01 | 2.13E+01 | 9.20E+01 |
| 41.53 | 93.65 | 9.14E+01 | 2.97E+01 | 9.13E+01 | 2.95E+01 | 9.17E+01 | 2.42E+01 | 8.90E+01 |
| 42.08 | 87.83 | 8.80E+01 | 2.60E+01 | 8.81E+01 | 2.58E+01 | 8.80E+01 | 2.13E+01 | 9.10E+01 |
| 41.45 | 90.5 | 9.11E+01 | 2.82E+01 | 9.09E+01 | 2.80E+01 | 8.98E+01 | 2.33E+01 | 9.60E+01 |
| 40.67 | 89.68 | 9.17E+01 | 2.55E+01 | 9.13E+01 | 2.52E+01 | 9.08E+01 | 2.18E+01 | 9.60E+01 |
| 41 | 85.2 | 8.95E+01 | 2.45E+01 | 8.96E+01 | 2.44E+01 | 9.00E+01 | 2.12E+01 | 9.10E+01 |
| 38.03 | 84.6 | 9.59E+01 | 2.52E+01 | 9.51E+01 | 2.50E+01 | 9.48E+01 | 2.16E+01 | 9.70E+01 |
| 29.98 | 90.25 | 7.05E+01 | 2.12E+01 | 7.03E+01 | 2.09E+01 | 6.98E+01 | 1.91E+01 | 6.90E+01 |
| 38.28 | 76.42 | 8.30E+01 | 2.27E+01 | 8.22E+01 | 2.25E+01 | 8.12E+01 | 2.01E+01 | 8.10E+01 |
| 45.07 | 83.57 | 8.17E+01 | 3.26E+01 | 8.22E+01 | 3.23E+01 | 8.28E+01 | 2.60E+01 | 8.00E+01 |
| 42.97 | 83.75 | 8.35E+01 | 2.59E+01 | 8.38E+01 | 2.56E+01 | 8.47E+01 | 2.19E+01 | 9.00E+01 |
| 42.77 | 84.6 | 8.41E+01 | 2.46E+01 | 8.45E+01 | 2.44E+01 | 8.54E+01 | 2.11E+01 | 8.40E+01 |
| 46.83 | 92.18 | 9.23E+01 | 3.69E+01 | 9.26E+01 | 3.66E+01 | 9.43E+01 | 2.85E+01 | 8.60E+01 |
| 44.88 | 93.22 | 9.44E+01 | 3.13E+01 | 9.47E+01 | 3.10E+01 | 9.36E+01 | 2.53E+01 | 9.10E+01 |
| 38.82 | 92.22 | 9.01E+01 | 3.02E+01 | 9.02E+01 | 3.00E+01 | 9.12E+01 | 2.45E+01 | 9.30E+01 |
| 32.32 | 90.08 | 7.82E+01 | 2.89E+01 | 7.83E+01 | 2.87E+01 | 7.98E+01 | 2.37E+01 | 8.00E+01 |
| 32.33 | 88.75 | 7.95E+01 | 2.21E+01 | 7.99E+01 | 2.17E+01 | 8.05E+01 | 1.96E+01 | 8.30E+01 |
| 35.27 | 75.55 | 8.01E+01 | 3.44E+01 | 7.90E+01 | 3.41E+01 | 7.85E+01 | 2.68E+01 | 6.90E+01 |
| 35.22 | 80.93 | 8.71E+01 | 2.42E+01 | 8.78E+01 | 2.41E+01 | 8.80E+01 | 2.09E+01 | 8.30E+01 |
| 34.9 | 76.88 | 8.05E+01 | 2.50E+01 | 7.97E+01 | 2.47E+01 | 7.93E+01 | 2.14E+01 | 8.20E+01 |
| 46.9 | 96.8 | 9.94E+01 | 4.25E+01 | 9.88E+01 | 4.23E+01 | 9.51E+01 | 3.10E+01 | 8.80E+01 |
| 42.87 | 100.55 | 1.03E+02 | 3.22E+01 | 1.03E+02 | 3.20E+01 | 1.03E+02 | 2.56E+01 | 1.02E+02 |
| 39.45 | 74.57 | 8.34E+01 | 2.30E+01 | 8.28E+01 | 2.28E+01 | 8.26E+01 | 2.03E+01 | 8.80E+01 |
| 42.22 | 75.98 | 8.79E+01 | 2.28E+01 | 8.86E+01 | 2.26E+01 | 9.26E+01 | 2.01E+01 | 9.50E+01 |
| 40.65 | 73.78 | 8.13E+01 | 2.04E+01 | 8.08E+01 | 2.00E+01 | 7.95E+01 | 1.85E+01 | 7.10E+01 |
| 40.92 | 81.43 | 9.06E+01 | 2.26E+01 | 9.09E+01 | 2.24E+01 | 9.15E+01 | 2.00E+01 | 9.40E+01 |
| 35.4 | 97.6 | 8.87E+01 | 3.19E+01 | 8.87E+01 | 3.17E+01 | 8.92E+01 | 2.52E+01 | 8.40E+01 |
| 42.83 | 80.18 | 8.68E+01 | 2.57E+01 | 8.72E+01 | 2.55E+01 | 8.71E+01 | 2.20E+01 | 8.80E+01 |
| 40.5 | 80.22 | 8.99E+01 | 2.66E+01 | 9.01E+01 | 2.63E+01 | 9.20E+01 | 2.24E+01 | 9.30E+01 |
| 35.03 | 85.2 | 8.98E+01 | 2.79E+01 | 9.05E+01 | 2.77E+01 | 9.01E+01 | 2.30E+01 | 8.80E+01 |
| 35.8 | 84 | 9.22E+01 | 2.78E+01 | 9.31E+01 | 2.77E+01 | 9.26E+01 | 2.30E+01 | 1.01E+02 |
| 36.12 | 86.68 | 9.05E+01 | 2.89E+01 | 9.03E+01 | 2.87E+01 | 8.97E+01 | 2.37E+01 | 9.50E+01 |
| 32.42 | 99.68 | 8.97E+01 | 2.94E+01 | 9.04E+01 | 2.92E+01 | 9.17E+01 | 2.41E+01 | 8.90E+01 |
| 35.23 | 101.7 | 9.70E+01 | 3.42E+01 | 9.84E+01 | 3.39E+01 | 1.01E+02 | 2.68E+01 | 9.20E+01 |
| 25.9 | 97.43 | 7.49E+01 | 4.30E+01 | 7.41E+01 | 4.27E+01 | 7.18E+01 | 3.13E+01 | 7.40E+01 |
| 27.7 | 97.28 | 7.60E+01 | 2.04E+01 | 7.51E+01 | 2.02E+01 | 7.38E+01 | 1.87E+01 | 6.60E+01 |
| 32.9 | 97.03 | 8.77E+01 | 2.20E+01 | 8.69E+01 | 2.15E+01 | 8.64E+01 | 1.96E+01 | 8.40E+01 |
| 29.97 | 95.35 | 7.48E+01 | 2.79E+01 | 7.43E+01 | 2.77E+01 | 7.46E+01 | 2.33E+01 | 7.20E+01 |
| 29.53 | 98.47 | 8.19E+01 | 2.90E+01 | 8.18E+01 | 2.89E+01 | 8.40E+01 | 2.39E+01 | 8.90E+01 |
| 33.97 | 98.48 | 9.02E+01 | 3.31E+01 | 9.03E+01 | 3.29E+01 | 8.91E+01 | 2.58E+01 | 9.20E+01 |
| 36.93 | 76.28 | 8.19E+01 | 1.85E+01 | 8.10E+01 | 1.82E+01 | 8.10E+01 | 1.72E+01 | 7.90E+01 |
| 38.95 | 77.45 | 8.47E+01 | 2.17E+01 | 8.39E+01 | 2.15E+01 | 8.18E+01 | 1.93E+01 | 9.30E+01 |
| 42.95 | 87.9 | 8.60E+01 | 2.53E+01 | 8.63E+01 | 2.52E+01 | 8.60E+01 | 2.15E+01 | 8.60E+01 |
| 37.78 | 81.12 | 9.20E+01 | 2.35E+01 | 9.27E+01 | 2.33E+01 | 9.65E+01 | 2.06E+01 | 9.10E+01 |
| 44.88 | 63.52 | 6.85E+01 | 2.35E+01 | 6.90E+01 | 2.31E+01 | 7.11E+01 | 2.09E+01 | 6.80E+01 |
| 46.8 | 71.38 | 8.63E+01 | 4.52E+01 | 8.57E+01 | 4.50E+01 | 8.51E+01 | 3.20E+01 | 7.50E+01 |
| 43.9 | 69.93 | 8.62E+01 | 2.53E+01 | 8.51E+01 | 2.49E+01 | 8.37E+01 | 2.18E+01 | 9.10E+01 |

Temperature

| X | Y | ESTIMATE | VARIANCE | ESTIMATE | VARIANCE | ESTIMATE | VARIANCE | TEMP |
|-------|--------|-------------|------------|-----------|------------|-----------|---------------|----------|
| | | Autokriging | 121 points | Cokriging | 121 points | Cokriging | 121+56 points | Original |
| 35.33 | 94.37 | 5.58E+01 | 1.76E+01 | 5.56E+01 | 1.74E+01 | 5.59E+01 | 1.72E+01 | 5.36E+01 |
| 34.73 | 92.23 | 6.01E+01 | 2.08E+01 | 5.98E+01 | 2.06E+01 | 6.00E+01 | 2.02E+01 | 5.72E+01 |
| 41.93 | 72.68 | 3.99E+01 | 1.06E+01 | 4.02E+01 | 1.04E+01 | 4.02E+01 | 1.04E+01 | 3.86E+01 |
| 38.85 | 77.03 | 4.63E+01 | 4.13E+00 | 4.70E+01 | 3.90E+00 | 4.62E+01 | 3.58E+00 | 4.67E+01 |
| 39.67 | 75.6 | 4.38E+01 | 5.36E+00 | 4.46E+01 | 5.07E+00 | 4.42E+01 | 4.86E+00 | 4.35E+01 |
| 30.22 | 81.88 | 6.80E+01 | 3.29E+00 | 6.83E+01 | 3.05E+00 | 6.83E+01 | 2.65E+00 | 6.83E+01 |
| 24.58 | 81.68 | 7.58E+01 | 1.96E+00 | 7.59E+01 | 1.58E+00 | 7.58E+01 | 9.13E-01 | 7.58E+01 |
| 32.52 | 84.95 | 6.14E+01 | 1.05E+01 | 6.12E+01 | 1.03E+01 | 6.13E+01 | 1.03E+01 | 6.17E+01 |
| 32.13 | 81.2 | 6.29E+01 | 7.38E+00 | 6.34E+01 | 7.09E+00 | 6.33E+01 | 7.00E+00 | 6.38E+01 |
| 41.98 | 87.9 | 3.51E+01 | 1.18E+01 | 3.52E+01 | 1.17E+01 | 3.53E+01 | 1.12E+01 | 3.58E+01 |
| 41.53 | 93.65 | 3.61E+01 | 1.62E+01 | 3.63E+01 | 1.60E+01 | 3.63E+01 | 1.59E+01 | 3.58E+01 |
| 42.08 | 87.83 | 3.50E+01 | 1.19E+01 | 3.51E+01 | 1.17E+01 | 3.52E+01 | 1.12E+01 | 3.66E+01 |
| 41.45 | 90.5 | 3.60E+01 | 1.45E+01 | 3.62E+01 | 1.44E+01 | 3.61E+01 | 1.43E+01 | 3.56E+01 |
| 40.67 | 89.68 | 3.74E+01 | 9.73E+00 | 3.76E+01 | 9.48E+00 | 3.76E+01 | 9.38E+00 | 3.68E+01 |
| 41 | 85.2 | 3.86E+01 | 1.04E+01 | 3.85E+01 | 1.02E+01 | 3.85E+01 | 1.02E+01 | 3.72E+01 |
| 38.03 | 84.6 | 4.99E+01 | 1.05E+01 | 4.99E+01 | 1.03E+01 | 5.01E+01 | 1.03E+01 | 5.19E+01 |
| 29.98 | 90.25 | 6.63E+01 | 3.93E+00 | 6.68E+01 | 3.64E+00 | 6.64E+01 | 3.28E+00 | 6.72E+01 |
| 38.28 | 76.42 | 4.97E+01 | 8.29E+00 | 5.03E+01 | 8.17E+00 | 4.99E+01 | 8.12E+00 | 4.87E+01 |
| 45.07 | 83.57 | 3.10E+01 | 1.86E+01 | 3.13E+01 | 1.85E+01 | 3.14E+01 | 1.82E+01 | 3.28E+01 |
| 42.97 | 83.75 | 3.45E+01 | 1.08E+01 | 3.48E+01 | 1.05E+01 | 3.48E+01 | 1.04E+01 | 3.45E+01 |
| 42.77 | 84.6 | 3.50E+01 | 9.59E+00 | 3.52E+01 | 9.37E+00 | 3.53E+01 | 9.28E+00 | 3.57E+01 |
| 46.83 | 92.18 | 2.57E+01 | 2.39E+01 | 2.57E+01 | 2.37E+01 | 2.53E+01 | 2.31E+01 | 2.48E+01 |
| 44.88 | 93.22 | 2.86E+01 | 1.65E+01 | 2.84E+01 | 1.62E+01 | 2.84E+01 | 1.61E+01 | 3.00E+01 |
| 38.82 | 92.22 | 4.46E+01 | 1.68E+01 | 4.44E+01 | 1.66E+01 | 4.42E+01 | 1.64E+01 | 4.30E+01 |
| 32.32 | 90.08 | 6.45E+01 | 1.54E+01 | 6.43E+01 | 1.53E+01 | 6.40E+01 | 1.52E+01 | 6.30E+01 |
| 32.33 | 88.75 | 6.27E+01 | 4.50E+00 | 6.23E+01 | 4.12E+00 | 6.25E+01 | 3.80E+00 | 6.34E+01 |
| 35.27 | 75.55 | 5.93E+01 | 2.16E+01 | 5.98E+01 | 2.13E+01 | 5.98E+01 | 2.08E+01 | 5.88E+01 |
| 35.22 | 80.93 | 5.57E+01 | 9.99E+00 | 5.52E+01 | 9.82E+00 | 5.54E+01 | 9.81E+00 | 5.58E+01 |
| 34.9 | 76.88 | 6.01E+01 | 8.62E+00 | 6.04E+01 | 8.27E+00 | 6.04E+01 | 8.10E+00 | 6.16E+01 |
| 46.9 | 96.8 | 2.69E+01 | 3.29E+01 | 2.72E+01 | 3.28E+01 | 2.89E+01 | 3.10E+01 | 2.57E+01 |
| 42.87 | 100.55 | 3.68E+01 | 1.95E+01 | 3.66E+01 | 1.93E+01 | 3.63E+01 | 1.90E+01 | 3.83E+01 |
| 39.45 | 74.57 | 4.72E+01 | 7.57E+00 | 4.79E+01 | 7.27E+00 | 4.79E+01 | 7.18E+00 | 4.62E+01 |
| 42.22 | 75.98 | 3.74E+01 | 7.63E+00 | 3.68E+01 | 7.43E+00 | 3.76E+01 | 7.36E+00 | 3.52E+01 |
| 40.65 | 73.78 | 4.41E+01 | 3.03E+00 | 4.50E+01 | 2.64E+00 | 4.44E+01 | 2.20E+00 | 4.30E+01 |
| 40.92 | 81.43 | 4.07E+01 | 6.82E+00 | 4.04E+01 | 6.63E+00 | 4.08E+01 | 6.50E+00 | 4.06E+01 |
| 35.4 | 97.6 | 5.34E+01 | 1.90E+01 | 5.36E+01 | 1.89E+01 | 5.35E+01 | 1.84E+01 | 5.29E+01 |
| 42.83 | 80.18 | 3.59E+01 | 1.07E+01 | 3.57E+01 | 1.05E+01 | 3.60E+01 | 1.05E+01 | 3.92E+01 |
| 40.5 | 80.22 | 4.17E+01 | 1.15E+01 | 4.12E+01 | 1.12E+01 | 4.10E+01 | 1.12E+01 | 4.14E+01 |
| 35.03 | 85.2 | 5.36E+01 | 1.44E+01 | 5.29E+01 | 1.42E+01 | 5.30E+01 | 1.40E+01 | 5.51E+01 |
| 35.8 | 84 | 5.21E+01 | 1.49E+01 | 5.11E+01 | 1.47E+01 | 5.15E+01 | 1.46E+01 | 5.30E+01 |
| 36.12 | 86.68 | 5.15E+01 | 1.49E+01 | 5.16E+01 | 1.47E+01 | 5.17E+01 | 1.46E+01 | 5.53E+01 |
| 32.42 | 99.68 | 6.03E+01 | 1.57E+01 | 5.97E+01 | 1.55E+01 | 5.97E+01 | 1.53E+01 | 6.06E+01 |
| 35.23 | 101.7 | 5.28E+01 | 2.01E+01 | 5.19E+01 | 1.99E+01 | 5.13E+01 | 1.96E+01 | 5.22E+01 |
| 25.9 | 97.43 | 7.18E+01 | 3.21E+01 | 7.27E+01 | 3.16E+01 | 7.33E+01 | 3.01E+01 | 7.25E+01 |
| 27.7 | 97.28 | 7.00E+01 | 3.96E+00 | 7.06E+01 | 3.63E+00 | 7.01E+01 | 3.23E+00 | 6.80E+01 |
| 32.9 | 97.03 | 6.09E+01 | 3.38E+00 | 6.11E+01 | 2.94E+00 | 6.10E+01 | 2.48E+00 | 6.05E+01 |
| 29.97 | 95.35 | 6.66E+01 | 1.36E+01 | 6.70E+01 | 1.34E+01 | 6.70E+01 | 1.34E+01 | 6.80E+01 |
| 29.53 | 98.47 | 6.68E+01 | 1.57E+01 | 6.66E+01 | 1.54E+01 | 6.61E+01 | 1.53E+01 | 6.60E+01 |
| 33.97 | 98.48 | 5.71E+01 | 2.12E+01 | 5.69E+01 | 2.10E+01 | 5.68E+01 | 2.03E+01 | 5.72E+01 |
| 36.93 | 76.28 | 5.59E+01 | 1.97E+00 | 5.63E+01 | 1.57E+00 | 5.59E+01 | 9.94E-01 | 5.61E+01 |
| 38.95 | 77.45 | 4.57E+01 | 5.88E+00 | 4.65E+01 | 5.64E+00 | 4.58E+01 | 5.45E+00 | 4.39E+01 |
| 42.95 | 87.9 | 3.37E+01 | 1.13E+01 | 3.39E+01 | 1.12E+01 | 3.39E+01 | 1.10E+01 | 3.46E+01 |
| 37.78 | 81.12 | 5.07E+01 | 8.03E+00 | 5.01E+01 | 7.82E+00 | 5.10E+01 | 7.75E+00 | 4.60E+01 |
| 44.88 | 63.52 | 3.66E+01 | 4.38E+00 | 3.65E+01 | 4.01E+00 | 3.72E+01 | 3.63E+00 | 3.58E+01 |
| 46.8 | 71.38 | 3.18E+01 | 3.74E+01 | 3.21E+01 | 3.72E+01 | 3.25E+01 | 3.47E+01 | 2.80E+01 |
| 43.9 | 69.93 | 3.63E+01 | 7.49E+00 | 3.70E+01 | 7.07E+00 | 3.68E+01 | 6.94E+00 | 3.54E+01 |